ASSET PURCHASES AS A REMEDY FOR THE ORIGINAL SIN REDUX

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The views in this address do not represent the official views of the Norges Bank and the OECD or of its member countries. The opinions expressed and arguments employed are those of the authors.
A foreign investor-induced bond sell-off leading to a surge in EME sovereign bond yields during the pandemic

- The COVID-19 shock entailed a sharp reversal in global risk appetite for EME sovereign bonds.
  - The increased foreign ownership of local-currency government securities transfers currency risk from sovereigns to foreign investors. → Dissipating original sin
  - However, this makes them more susceptible to reversals in risk sentiment; Borri (2018), Carstens and Shin (2019) and Bertaut et al. (2021). → Original sin redux

Note: The average of HP-filtered series for Chile, Colombia, Hungary, Indonesia, India, Korea, Mexico, the Philippines, Poland, Romania, Thailand, Turkey and South Africa for the period of 2004Q1-2020Q3. Foreign holding share of local-currency 10-year government bonds is shown as percentage point deviation from the trend. Excess yield is over the US short-term rate and in annualised basis points.
Source: OECD Economic Outlook 108 Database; Refinitiv; and IMF Sovereign Debt Investor Base Database.
Compensate for the bond sell-off by international investors and prevent surges in local benchmark bond yields.

An estimated average bond yield reduction in the range of 15-30 bps from QE policies in EMEs without necessarily leading to currency depreciation

What we do

- Estimate a medium-scale New Keynesian small open economy model with Bayesian techniques
  - Replicate the representative asset purchase-deploying EME (average of 13), benefiting from the classifications in Arslan et al. 2020 and IMF GFSR 2020 Ch-2

- Quantify the efficacy of local-currency asset purchases by central banks in EMEs in reducing excess sovereign bond yields during risk-off episodes
  - Analyse rule-based asset purchases in mitigating bond sell-off shocks.

- Run post-pandemic counterfactual trajectories under alternative AP policies

- Offer a solution to the puzzle of stable EME currencies upon asset purchases during the pandemic
Key findings

• The repercussions of the original sin redux are a pressure on banks’ to fund the government.
  – The currency mismatch that banks face further reduces their borrowing capacity.

• Bond purchases ease financial conditions without leading to ER depreciation/inflation.
  – Prevents financial crowding out effects (Bocola, 2016; Kirchner and van Wijnbergen, 2016; Chari et al., 2020) and strengthen bank balance sheets
  – Reduced capital outflows (appreciating currency) and stronger supply of credit (lowering spreads)

• Private asset purchases are roughly three times as more effective as bond purchases.
  – Multiplies the credit base directly, whereas government bond purchases mainly boost prices.

• Bond yield reductions (~22 bps per annum) from asset purchases during the pandemic could have persisted only under large-scale programmes à la advanced economies.
  – For government bond and (private security) purchases of ~ 20% (10%) of GDP.
  – Yet, even LSAPs are not inflationary when monetary policy frameworks are credible.

Literature
Extensions: Risks and limitations

- **De-anchored inflation expectations →** Asset purchases result in **higher and more persistent** inflation and reduce excess bond yields by less.

- **Costly asset purchases → Balance sheet risks** posed on the consolidated government budget by reduced remitted profits from the central bank → Hampers the effectiveness of QE policies

- If policy rates were at their **ELB**? → Efficacy of asset purchases in reducing nominal bond yields doesn’t change much.
  - Two opposing effects: Higher real bond yields under **elevated domestic funding costs**; lower inflation due to a more vigilant conventional policy and **depressed aggregate demand**.

- No reduction in **global** interest rates → Asset purchases continue to reduce excess bond yields, while overall financial conditions are tighter relative to the baseline.
A model of government debt, financial intermediaries and asset purchases

Households
- Short-term, LC deposits
- Security claims priced at $q$ against physical capital demand

Foreign lenders
- Short-term, FC debt
- Long-term, LC bonds

Banks
- Long-term, LC bonds

Government
- Long-term, LC bonds
- Private securities, private QE

Central bank
- Long-term, LC bonds, public QE
- Sets the short-term policy interest rate
- Issues high powered money
-_issues short-term debt to banks to finance asset purchase policies

Intermediate good producers
- Monopolistically competitive and incur price setting costs.
- Purchases investment goods at the price $q$.
- Sell to domestic and foreign final good producers.

Final good producers
- Repackage domestic and imported intermediate good varieties into a final good.
- Satisfy demand from capital producers, government and households.

Note: LC and FC stand for “local-currency” and “foreign-currency”.

• Modify the canonical banking sector model by Gertler and Kiyotaki (2010) to have government debt and banks’ foreign debt

\[ q_t l_t + q_t^g b_t^g = d_t + b_t^* + n_t \]

• Banks face the incentive compatibility constraint:

\[ V_t > \lambda \cdot (q_t l_t + \omega_g q_t^g b_t^g - \omega_d d_t) \]

• 0 < \omega_g, \omega_d < 1 \rightarrow bonds are safer than private securities and domestic depositors can better monitor banks.

• The solution: (i) an endogenous leverage constraint:

\[ q_t l_t + \omega_g q_t^g b_t^g - \omega_d d_t = \kappa_t n_t \]

(ii) an interest rate ranking of

\[ E_t[\Lambda_{t,t+s} R_{kt+s}] > E_t[\Lambda_{t,t+s} R_{t+s}^g] > E_t[\Lambda_{t,t+s} R_{t+s}] > E_t[\Lambda_{t,t+s} R_{t+s}^*] \]
Asset purchase policies and government

- Private security and government bond market equilibrium:
  
  \[
  q_t \bar{l}_t = q_t l_t + q_t l^{CB}_t \\
  q_t^g \bar{b}^g = q_t^g b_t^g + q_t^g b_t^{g*} + q_t^g b_t^{gCB}
  \]

- Foreign investor demand for government bonds:  
  
  \[
  \log \left( \frac{b_t^{g*}}{b_t^g} \right) = \rho^{g*} \log \left( \frac{b_t^{g*}}{b_t^{g* - 1}} \right) + (1 - \rho^{g*}) \left[ \nu_t^{g*} \log(\Psi_t) \right] + \epsilon_t^{g*}, \quad \nu_t^{g*} < 0
  \]

- Asset purchases act as financial multipliers:
  
  \[
  q_t l^{CB}_t = \phi_t^l q_t \bar{l}_t (1 - \tau^{CB}) \\
  q_t^g b_t^{gCB} = \phi_t^g q_t^g \bar{b}^g (1 - \tau^{gCB})
  \]

  \[
  q_t \bar{l}_t = \frac{1}{1 - \phi_t^l (1 - \tau^{CB})} q_t l_t \\
  q_t^g \bar{b}^g = \frac{1}{1 - \phi_t^g (1 - \tau^{gCB})} \left[ q_t^g b_t^g + q_t^g b_t^{g*} \right]
  \]

- \( 0 < \tau^{CB}, \tau^{CB} < 1 \rightarrow \) Costly asset purchases lead to lower multipliers.
Asset purchase policies and government ctd.

- Bond and private security purchase policy: Fratto et al. (2021)
  \[ \varphi_t^g = \rho \varphi^g \varphi_{t-1}^g + (1 - \rho \varphi^g) \left[ \nu_g \left( \frac{q_t^g b_{tg}^{g*} / y_t}{q^g b^g / y} \right) + \epsilon_t^{g \varphi} \right] + \nu_g < 0 \]
  \[ \varphi_t^l = \rho \varphi^l \varphi_{t-1}^l + (1 - \rho \varphi^l) \left[ \nu_l E_t \left( \frac{R_{kt+1} - R_{t+1}}{R_k - R} \right) \right] + \epsilon_t^{l \varphi} + \nu_l > 0 \]

- Consolidated government flow budget constraint
  \[ g_t + (R_t^g - 1)b_g = \frac{M_t - M_{t-1}}{p_t} + \tau_t + (R_t^g - R_t)q_{t-1}^g b_{tg}^{gCB} + (R_{kt} - R_t)q_{t-1}l_{t-1}^{CB} \]
  \[ q_{t-1}^g b_{tg}^{gCB} = \varphi_{t-1}^g q_{t-1}^g \overline{b^g} (1 - \tau^{gCB}) \]
  \[ q_{t-1}l_{t-1}^{CB} = \varphi_{t-1}^l q_{t-1}l_{t-1}^{lCB} = \varphi_{t-1}^l q_{t-1}l_{t-1}^{lCB} (1 - \tau^{CB}) \]
  - Purchases are financed by short-term debt akin to bank deposits.
  - Remitted profits are reduced by efficiency costs.

- Conventional monetary policy
  \[ \log \left( \frac{1 + r_{nt}}{1 + \bar{r}_n} \right) = \rho^{r_n} \log \left( \frac{1 + r_{nt-1}}{1 + \bar{r}_n} \right) + (1 - \rho^{r_n}) \left[ \varphi_{\pi} \log \left( \frac{\pi_t}{\bar{\pi}} \right) + \varphi_{y} \log \left( \frac{y_t}{\bar{y}} \right) + \varphi_{\epsilon} \log \left( \frac{\eta_t}{\bar{\eta}} \right) \right] \]
Repercussions of the original sin redux at play: transmission of government bond sell-off shocks

- Foreigner investors sell off LC bonds

- Domestic banks’ bond holdings

- Excess bond yields

- Inflation

- Financial crowding out

- Lending to non-financial firms

- Real investment

- Real bond prices

- Currency depreciates

- Tightening financial conditions

- Capital outflows

- Loan-deposit spreads

- Bank net worth

- Banks’ foreign borrowing

- Private asset prices

Note: “Bonds” refer to domestic-currency, long-term EME sovereign bonds.
Bond purchases mainly work by easing the stress on domestic balance sheets

Note: “Bonds” refer to domestic-currency, long-term EME sovereign bonds.
Private security purchases act as a direct financial multiplier

Foreigner investors sell off LC bonds → Central bank purchases private securities → Domestic banks’ bond holdings → Bond yield rises are lower → Inflation rises by less

Financial crowding out

Directly mitigate the ensuing decline in lending to firms → Investment falls by less → Stronger real bond prices → Currency depreciates by less

Lower decline in asset prices → Credit spreads rise by less → Bank net worth stronger → Banks can borrow more

Mitigates tightening in financial conditions

Capital outflows; mostly due to foreign bond sell-off

Note: “Bonds” refer to domestic-currency, long-term EME sovereign bonds.
Rule-based asset purchases mitigate the effects of the original sin redux

Note: Impulse-response functions of selected model variables to an orthogonal bond sell-off shock of 1.5% of GDP. Deviations from the steady state. Asset purchase-to-GDP ratio is representative of EME central bank sovereign bond purchases during the COVID-19 crisis. Increases in the real exchange rate denote depreciations. Excess yield is over the US short-term rate.
Asset purchases have temporarily eased financial conditions during the pandemic

<table>
<thead>
<tr>
<th>2020Q2</th>
<th>Excess LC government bond yields</th>
<th>Real exchange rate</th>
<th>Monetary policy rate</th>
<th>Asset purchases</th>
<th>Inflation</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annualised basis point change</td>
<td>% change</td>
<td>Annualised basis point change</td>
<td>% of GDP</td>
<td>Annualised basis point change</td>
<td>% change</td>
</tr>
<tr>
<td>Aggressive public QE</td>
<td>80 [75, 85]</td>
<td>2.3 [0.8, 3.9]</td>
<td>-127 [-172, -81]</td>
<td>8.4</td>
<td>-212 [-332, -89]</td>
<td>-16.3 [-19.8, -12.9]</td>
</tr>
<tr>
<td>Aggressive public QE²</td>
<td>72 [66, 75]</td>
<td>2.0 [0.4, 3.6]</td>
<td>-133 [-179, -87]</td>
<td>21.0</td>
<td>-220 [-341, -97]</td>
<td>-16.0 [-19.4, -12.6]</td>
</tr>
<tr>
<td>Aggressive private QE²</td>
<td>72 [67, 77]</td>
<td>1.8 [0.3, 3.3]</td>
<td>-133 [-177, -88]</td>
<td>10.2</td>
<td>-218 [-337, -97]</td>
<td>-14.4 [-17.9, -11.0]</td>
</tr>
</tbody>
</table>

Note: Effects of adopting counterfactual quantitative easing policies during the COVID-19 crisis. Changes relative to the HP-filtered trend at quarterly frequency. Increases in the real exchange rate denote depreciations. Asset purchases are as a share of steady state GDP. Ranges in square brackets are 90% confidence intervals. 1. This row presents 2020Q2 cross-country averages of the actual data matched by the estimated model. The remaining rows represent the outcome of counterfactual exercises. 2. Asset purchase sizes in these rows are calibrated to match the 6-day average bond yield compression in EMEs as estimated by the IMF-GFSR October, 2020.
Discussion and policy implications

• The policy punchline is that asset purchases in credible EMEs can be useful to guide price discovery in times of stress but not to manage aggregate demand over the business cycle.

• Even though fiscal multipliers are larger when government borrows more from foreigners (Priftis and Zimic, 2020; Broner et al., 2021), a wider foreign investor base could have destabilising effects in stress episodes.

• By mitigating financial shocks, asset purchases do not derail the currency and inflation outlook in countries with inflation expectations that are in check and currencies that float freely → Conjecture by Benigno et al. 2020.

• Permanent expansion of the central bank’s balance sheet can be considered to explore the effects on inflation dynamics.

• The framework can also be extended to a two-country setup to account for spillovers from large, advanced economy asset purchase policies to EMEs.
THANK YOU! 😊

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Related literature

• **Gertler and Karadi (2013), Sims and Wu (2021)**
  – Use the tractable long-term bonds formulation as in the latter contribution.
  – Abstract from currency mismatches on banks and the bond sell-off by foreigners.

• **Dedola et al. (2013)**
  – Real economy with no monetary policy and currency dynamics, no bond purchases.

• **Alpanda and Kabaca (2020), Kolasa and Wesolowski (2020)**
  – Abstract from balance sheet adjustments of banks in response to changes in the supply of government bonds and the financial crowding out channel.

• **Bocola (2016), Kirchner and van Wijnbergen (2016), Chari et al. (2020)**
  – Feature the financial crowding out channel in closed economies but abstract from QE.

• **Priftis and Zimic (2020), Broner et al. (2021)**
  – Fiscal multipliers are higher when government borrows more from foreigners. We look from the angle of destabilising effects of a wider foreign investor base.
Bond purchases are less effective when inflation expectations are de-anchored

Note: Deviations from the steady state in response to a bond sell-off shock. The solid lines are the case of a public asset purchases policy programme that reaches 4.5% of GDP at the peak. The dashed lines differ from this case by assuming that intermediate good producers partially take previous period’s rate of inflation rather than the target inflation as their reference in computing their menu cost. 10-year spreads are the difference between the real yield-to-maturity of government bonds and the real short-term deposit rate. Nominal excess yield is over the US short-term rate.
Bond purchases stabilise excess yields even when central bank intermediation is imperfect

Note: Deviations from the steady state. The solid lines are the case of a public asset purchases policy programme that reaches 4.5% of GDP at the peak in response to a concomitant bond sell-off shock. The dashed lines differ from this case by assuming that there are efficiency costs (30% leakage) to the intermediation of government bonds by the central bank. Nominal excess yield is over the US short–term rate.
Financial repercussions of the pandemic on EMEs have been weaker than the GFC

Note: The average of HP-filtered series for Chile, Colombia, Hungary, Indonesia, India, Korea, Mexico, the Philippines, Poland, Romania, Thailand, Turkey and South Africa for the period of 2004Q1-2020Q3. National account variables and real depreciation are in per cent deviation from the trend; interest rates, EMBIG spreads, and CPI inflation are in annualised basis point deviation from the trend; foreign holding share of local currency government bonds is shown as percentage point deviation from the trend. Excess yield is over the US short-term rate.

Source: OECD Economic Outlook 108 Database; Refinitiv; and IMF Sovereign Debt Investor Base Database.
Apply the Macaulay (1938) formulation with geometrically decaying payment streams $\kappa_g, \kappa_g(1 - \delta_g), \kappa_g(1 - \delta_g)^2, \ldots, 0$ where $\kappa_g$ is the periodic real coupon payment in terms of the numeraire and $\delta_g$ is the periodic decay rate.

Avoids tracking a large dimensional state space of historical non-matured debt balances and is flexible, as the decay rate can be calibrated to match equilibrium bond maturities of 10 years.

Defines the gross real yield and net real yield-to-maturity as

$$R_{t+1}^g = \frac{\kappa_g(1 - \delta_g)q_t^g}{q_{t+1}^g}$$

and

$$r_t^g = \frac{\kappa_g}{q_t^g} - \delta_g.$$
Uncovered interest parity deviations

\[ R_{t+1} = (1 + r_{nt}) \frac{P_t}{P_{t+1}} \]

\[ R_{t+1}^* = \Psi_t (1 + r_{n}^*) \frac{S_{t+1}}{S_t} \frac{P_t}{P_{t+1}} \quad \forall t, \]

\[ \Psi_t = \exp \left[ \psi \int_n^d f dt \right] \]
Decomposition of excess bond yields

\[ EY_t^g = (R_t^{YTM,g} - R_t)\pi_{t+1} + (R_t - R_t^*)\pi_{t+1} + R_t^*\pi_{t+1} - R_{nt}^* \]

- Term premium
- Financial amplification
- Foreign borrowing costs
## Steady state and policy parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preferences</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quarterly discount factor</td>
<td>( \beta )</td>
<td>0.9968</td>
<td>Annualized real deposit rate of 1.3%</td>
</tr>
<tr>
<td>Labor disability parameter</td>
<td>( \chi )</td>
<td>397.7</td>
<td>Steady state hours worked of 0.33</td>
</tr>
<tr>
<td>Utility parameter for real money balances</td>
<td>( p )</td>
<td>0.0159</td>
<td>Output to M1 ratio of 6.41</td>
</tr>
<tr>
<td>Share of domestic consumption goods</td>
<td>( w )</td>
<td>0.5</td>
<td>Consumption to GDP ratio of 0.59</td>
</tr>
<tr>
<td><strong>Financial Intermediaries</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fraction of diverted bank loans</td>
<td>( \lambda )</td>
<td>0.79</td>
<td>Annualized domestic credit spread of 416 bps.</td>
</tr>
<tr>
<td>Proportional transfer to new bankers</td>
<td>( \epsilon^b )</td>
<td>0.0026</td>
<td>Commercial bank leverage of 6.41</td>
</tr>
<tr>
<td>Fraction of non-diverted domestic deposits</td>
<td>( \omega_d )</td>
<td>0.1769</td>
<td>Foreign funding share of banks of 31.72%</td>
</tr>
<tr>
<td>Fraction of diverted government bonds</td>
<td>( \omega_g )</td>
<td>0.4230</td>
<td>Annualized 10-year gov. bond spread of 123 bps.</td>
</tr>
<tr>
<td>Survival probability of bankers</td>
<td>( \theta^s )</td>
<td>0.9200</td>
<td>Survival duration of 4.17 years for bankers</td>
</tr>
<tr>
<td><strong>Firms</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of capital in output</td>
<td>( \alpha )</td>
<td>0.3</td>
<td>Labor share of output of 0.70</td>
</tr>
<tr>
<td>Share of domestic investment goods</td>
<td>( \omega_I )</td>
<td>0.8933</td>
<td>Investment to GDP ratio of 0.27</td>
</tr>
<tr>
<td>Steady-state utilization rate</td>
<td>( \bar{\mu} )</td>
<td>1</td>
<td>Normalization</td>
</tr>
<tr>
<td>Scaling parameter for utilization rate</td>
<td>( \varphi_{\bar{\mu}} )</td>
<td>0.0424</td>
<td>Steady-state utilization rate of 1</td>
</tr>
<tr>
<td>Depreciation rate of capital</td>
<td>( \delta )</td>
<td>0.1157</td>
<td>Total private credit to GDP ratio of 1.8</td>
</tr>
<tr>
<td><strong>External sector</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average foreign output</td>
<td>( \bar{y}^f )</td>
<td>0.1324</td>
<td>Trade volume to GDP ratio of 0.71</td>
</tr>
<tr>
<td>Average foreign nominal policy rate</td>
<td>( R^f_s )</td>
<td>1.001</td>
<td>Average effective U.S. federal funds rate</td>
</tr>
<tr>
<td><strong>Monetary Authority and Government</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average annual gross inflation</td>
<td>( \Omega )</td>
<td>1</td>
<td>Normalization</td>
</tr>
<tr>
<td>Steady state gov. expenditure to GDP ratio</td>
<td>( g_s )</td>
<td>0.1450</td>
<td>Gov. spending to GDP ratio of 0.145</td>
</tr>
<tr>
<td>Quarterly government debt limit</td>
<td>( \delta_s )</td>
<td>0.0955</td>
<td>Local currency government bonds to GDP ratio 0.243</td>
</tr>
<tr>
<td>Fraction of total LC gov. bonds held by foreigners</td>
<td>( \zeta )</td>
<td>0.17</td>
<td>Foreign holdings share of total local currency gov. bonds</td>
</tr>
<tr>
<td>Decay rate of real long-term government bonds</td>
<td>( \delta_g )</td>
<td>0.0189</td>
<td>10 years of maturity of long-term government bonds</td>
</tr>
<tr>
<td>Coupon rate of real long-term government bonds</td>
<td>( \kappa_g )</td>
<td>0.0198</td>
<td></td>
</tr>
<tr>
<td>Steady-state fraction of gov. bond purchases by central bank</td>
<td>( \phi_g )</td>
<td>0.0001/0.0001/0.5/0.8</td>
<td>Policy experiment</td>
</tr>
<tr>
<td>Steady-state fraction of private asset purchases by central bank</td>
<td>( \phi_p )</td>
<td>0.0001/0.0001/0.15/0.3</td>
<td>Policy experiment</td>
</tr>
<tr>
<td>Persistence of public QE policy</td>
<td>( \rho_\beta )</td>
<td>0.9/0/0/0</td>
<td>Policy experiment</td>
</tr>
<tr>
<td>Persistence of private QE policy</td>
<td>( \rho_s )</td>
<td>0.9/0/0/0</td>
<td>Policy experiment</td>
</tr>
<tr>
<td>Response coeff. of public QE policy to bond sell-off</td>
<td>( \nu_\beta )</td>
<td>0/-0.17/-2/-4</td>
<td>Policy experiment</td>
</tr>
<tr>
<td>Response coeff. of private QE policy to credit spreads</td>
<td>( \nu_s )</td>
<td>0/8.62/0/0</td>
<td>Policy experiment</td>
</tr>
<tr>
<td>Discretionary shock to public QE policy</td>
<td>( \sigma_{\phi_g} )</td>
<td>3.16/0/0/0</td>
<td>1.5% of GDP</td>
</tr>
<tr>
<td>Discretionary shock to private QE policy</td>
<td>( \sigma_{\phi_p} )</td>
<td>0.33/0/0/0</td>
<td>0.5% of GDP</td>
</tr>
</tbody>
</table>

**Note:** The table includes parameters with values and descriptions that are relevant for macroeconomic models, focusing on steadystate and policy variables. Some variables are set to specific values such as the target for the annualized real deposit rate, the target for the output to M1 ratio, and the survival rate for bankers, among others.
## Marginal Prior and Posterior Distributions of Parameters that Affect Dynamics

<table>
<thead>
<tr>
<th>Households</th>
<th>Description</th>
<th>Distribution</th>
<th>Prior</th>
<th>Posterior</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>Risk aversion</td>
<td>$N$</td>
<td>2</td>
<td>0.1</td>
</tr>
<tr>
<td>$h_b$</td>
<td>Habit persistence in consumption</td>
<td>$\beta$</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td>$\xi$</td>
<td>Inverse Frisch elasticity</td>
<td>$N$</td>
<td>3</td>
<td>0.1</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Elasticity of substitution between H and F consumption goods</td>
<td>$N$</td>
<td>0.5</td>
<td>0.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Firms</th>
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</tr>
</thead>
<tbody>
<tr>
<td>$\varphi_H$</td>
<td>Rotemberg adjustment cost for H goods</td>
<td>$\Gamma$</td>
<td>150</td>
<td>10</td>
</tr>
<tr>
<td>$\varphi_F$</td>
<td>Rotemberg adjustment cost for F goods</td>
<td>$\Gamma$</td>
<td>150</td>
<td>10</td>
</tr>
<tr>
<td>$\psi$</td>
<td>Investment adjustment costs</td>
<td>$\Gamma$</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Elasticity of utility with respect to I/K ratio</td>
<td>$\Gamma$</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>$\gamma_i$</td>
<td>Elasticity of substitution between H and F investment goods</td>
<td>$N$</td>
<td>0.25</td>
<td>0.1</td>
</tr>
<tr>
<td>$\omega_i$</td>
<td>Share of H investment goods</td>
<td>$\beta$</td>
<td>0.25</td>
<td>0.1</td>
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<table>
<thead>
<tr>
<th>External sector</th>
<th>Description</th>
<th>Distribution</th>
<th>Prior</th>
<th>Posterior</th>
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<tr>
<td>$\Gamma_X$</td>
<td>Terms-of-trade elasticity of exports</td>
<td>$N$</td>
<td>1</td>
<td>0.1</td>
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<tr>
<td>$\nu^*$</td>
<td>Sensitivity of foreign-held LC bonds to risk premium</td>
<td>$N$</td>
<td>-77</td>
<td>10</td>
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<tr>
<td>$\psi_{rp1}$</td>
<td>Debt-elastic risk premium</td>
<td>$\Gamma$</td>
<td>0.0015</td>
<td>0.0005</td>
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<td>$\nu_F$</td>
<td>Persistence of the export demand</td>
<td>$\beta$</td>
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<th>Monetary sector</th>
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<tr>
<td>$\rho_{rn}$</td>
<td>Policy rule inertia</td>
<td>$\beta$</td>
<td>0.7</td>
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<tr>
<td>$\varphi_{\Pi}$</td>
<td>Response to inflation</td>
<td>$N$</td>
<td>2</td>
<td>0.3</td>
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<tr>
<td>$\varphi_Y$</td>
<td>Response to output gap</td>
<td>$\Gamma$</td>
<td>0.25</td>
<td>0.23523</td>
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<tr>
<td>$\varphi_E$</td>
<td>Response to nominal exchange rate</td>
<td>$\Gamma$</td>
<td>0.3</td>
<td>0.2</td>
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Marginal prior and posterior distributions of shock parameters

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<tr>
<th>Shock persistence</th>
<th>Description</th>
<th>Prior Distribution</th>
<th>Prior Mean</th>
<th>Prior Standard deviation</th>
<th>Prior Mode</th>
<th>Prior Standard deviation</th>
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<tr>
<td>$\rho_A$</td>
<td>Temporary productivity</td>
<td>$\beta$</td>
<td>0.5</td>
<td>0.2</td>
<td>0.05</td>
<td>0.08</td>
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<td>$\rho_c$</td>
<td>Consumption preference</td>
<td>$\beta$</td>
<td>0.5</td>
<td>0.2</td>
<td>0.45</td>
<td>0.14</td>
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<tr>
<td>$\rho_i$</td>
<td>Marginal efficiency of investment</td>
<td>$\beta$</td>
<td>0.5</td>
<td>0.2</td>
<td>0.16</td>
<td>1.0</td>
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<tr>
<td>$\rho_g$</td>
<td>Government spending</td>
<td>$\beta$</td>
<td>0.5</td>
<td>0.2</td>
<td>0.13</td>
<td>0.04</td>
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<tr>
<td>$\rho_{rp}$</td>
<td>Country risk premium</td>
<td>$\beta$</td>
<td>0.5</td>
<td>0.2</td>
<td>0.86</td>
<td>0.01</td>
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<tr>
<td>$\rho_{y^*}$</td>
<td>Foreign output</td>
<td>$\beta$</td>
<td>0.5</td>
<td>0.2</td>
<td>0.65</td>
<td>0.19</td>
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<tr>
<td>$\rho_{R_n}$</td>
<td>US interest rate</td>
<td>$\beta$</td>
<td>0.5</td>
<td>0.2</td>
<td>0.78</td>
<td>0.04</td>
</tr>
<tr>
<td>$\rho_e$</td>
<td>Price mark-up</td>
<td>$\beta$</td>
<td>0.5</td>
<td>0.2</td>
<td>0.27</td>
<td>0.17</td>
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<tr>
<td>$\rho_\zeta$</td>
<td>Global bond sell-off</td>
<td>$\beta$</td>
<td>0.5</td>
<td>0.2</td>
<td>0.78</td>
<td>0.01</td>
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<td>$\rho_\omega$</td>
<td>Import demand</td>
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<td>0.5</td>
<td>0.2</td>
<td>0.87</td>
<td>0.07</td>
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<td>$\rho_{\kappa_g}$</td>
<td>Government bond coupon</td>
<td>$\beta$</td>
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<td>0.2</td>
<td>0.27</td>
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<table>
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<tr>
<th>Shock standard deviation</th>
<th>Description</th>
<th>Distribution</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Mode</th>
<th>Standard deviation</th>
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<tbody>
<tr>
<td>$\sigma_A$</td>
<td>Temporary productivity</td>
<td>$\Gamma^{-1}$</td>
<td>10</td>
<td>200</td>
<td>9.73</td>
<td>0.78</td>
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<td>$\sigma_c$</td>
<td>Consumption preference</td>
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<td>10</td>
<td>200</td>
<td>5.79</td>
<td>27.71</td>
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<td>$\sigma_i$</td>
<td>Marginal efficiency of investment</td>
<td>$\Gamma^{-1}$</td>
<td>10</td>
<td>200</td>
<td>18.48</td>
<td>2.50</td>
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<td>$\sigma_g$</td>
<td>Government spending</td>
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<td>200</td>
<td>0.96</td>
<td>0.44</td>
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<td>$\sigma_{rp}$</td>
<td>Country risk premium</td>
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<td>0.08</td>
<td>5.28e-03</td>
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<td>$\sigma_{y^*}$</td>
<td>Foreign output</td>
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<td>3.8163</td>
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<td>$\sigma_{R_n}$</td>
<td>Domestic policy rate</td>
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<td>0.06</td>
<td>0.01</td>
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<tr>
<td>$\sigma_{R_n}$</td>
<td>US interest rate</td>
<td>$\Gamma^{-1}$</td>
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<td>200</td>
<td>0.1</td>
<td>2.91e-03</td>
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<tr>
<td>$\sigma_e$</td>
<td>Price mark-up</td>
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<td>200</td>
<td>74.06</td>
<td>23.2</td>
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<tr>
<td>$\sigma_\zeta$</td>
<td>Global bond sell-off</td>
<td>$\Gamma^{-1}$</td>
<td>3</td>
<td>200</td>
<td>3.26</td>
<td>0.069</td>
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<tr>
<td>$\sigma_\omega$</td>
<td>Import demand</td>
<td>$\Gamma^{-1}$</td>
<td>3</td>
<td>200</td>
<td>1.23</td>
<td>0.45</td>
</tr>
<tr>
<td>$\sigma_{\kappa_g}$</td>
<td>Government bond coupon</td>
<td>$\Gamma^{-1}$</td>
<td>10</td>
<td>200</td>
<td>11.50</td>
<td>0.44</td>
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</table>

Note: Standard deviations of shocks are multiplied by 100.
Easing financial conditions without currency depreciation or inflation risks

Note: Impulse-response functions of selected model variables to discretionary quantitative easing policy shocks. Deviations from the steady state. Asset purchase-to-GDP ratio is representative of EME central bank sovereign bond purchases during the COVID-19 crisis. Increases in the real exchange rate denote depreciations. Excess yield is over the US short-term rate.
Private QE is more successful in mitigating country risk premium shocks

**Note:** Impulse-response functions of selected model variables to an orthogonal country risk premium shock. Deviations from the steady state. The country risk premium shock is calibrated to replicate 172 basis points increase (from 2020Q1 to 2020Q2) in the cyclically adjusted annualised EMBIG bond spreads in the average EME economy. Public asset purchase policy is calibrated to replace foreign investors that endogenously sell-off government bonds in the face of increasing country risk premium. Private asset purchase policy is calibrated to imply a similar asset purchases magnitude to public asset purchases. Interest rate rule features an inflation coefficient of 1.5 to reflect a fear of floating. Increases in the real exchange rate denote depreciations. Funding spread is the positive UIP deviation beyond country risk premium and expected depreciation that emerges due to financial frictions. Excess yield is over the US short-term rate.
Private security purchases ease financial conditions even when central bank intermediation is imperfect

Note: Deviations from the steady state. The solid lines are the case of a private asset purchases policy programme that reaches 0.5% of GDP at the peak in response to a **country risk premium shock of 172 basis points** in annualised terms. The dashed lines differ from this case by assuming that there are efficiency costs in intermediation of private securities by the central bank. Nominal excess yield is over the US short–term rate.
Counterfactuals for the COVID-19 crisis with full set of variables

Note: Effects of adopting baseline and counterfactual quantitative easing policies during the COVID-19 crisis. Deviations from a HP-trend. The solid line is the basis for filtering shocks to match variable paths in the out-of-estimation sample of 2020Q1-2020Q3. Foreign-held government bonds share is assumed to stay at its 2020Q2 level relative to its trend due to lack of data. Private asset purchase policy positively responds to increases in loan-deposit spreads. Excess yield is over the US short-term rate.
Bond yield reductions from asset purchases persist only under large-scaled programmes

Note: Effects of adopting baseline and counterfactual quantitative easing policies during the COVID-19 crisis. Deviations from a HP-trend. The solid line is the basis for filtering shocks to match variable paths in the out-of-estimation sample of 2020Q1-2020Q3. Foreign-held government bonds share is assumed to stay at its 2020Q2 level relative to its trend due to lack of data. Private asset purchase policy positively responds to increases in the empirical path of loan-deposit spreads. Excess yield is over the US short-term rate.
The effects of QE policies are still short-lived under no monetary policy easing

### 2020Q2

<table>
<thead>
<tr>
<th>2020Q2</th>
<th>Excess LC government bond yields</th>
<th>Real exchange rate</th>
<th>Monetary policy rate</th>
<th>Asset purchases</th>
<th>Inflation</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annualised basis point change</td>
<td>% change</td>
<td>Annualised basis point change</td>
<td>% of GDP</td>
<td>Annualised basis point change</td>
<td>% change</td>
</tr>
<tr>
<td>No QE policy</td>
<td>95 [89, 100]</td>
<td>1.7 [0.2, 3.2]</td>
<td>-6 [-51, 40]</td>
<td>n.a.</td>
<td>-226 [-345, -105]</td>
<td>-17.0 [-20.5, -13.6]</td>
</tr>
<tr>
<td>Aggressive public QE</td>
<td>72 [67, 77]</td>
<td>0.7 [-0.8, 2.3]</td>
<td>-6 [-52, -40]</td>
<td>21.0 [20.1, 21.3]</td>
<td>-249 [-370, -126]</td>
<td>-16.3 [-19.8, -12.9]</td>
</tr>
<tr>
<td>Aggressive private QE</td>
<td>75 [70, 80]</td>
<td>0.5 [-1.0, 2.0]</td>
<td>-6 [-51, 39]</td>
<td>10.2 [10.1, 10.2]</td>
<td>-245 [-363, -124]</td>
<td>-14.9 [-18.4, -11.4]</td>
</tr>
</tbody>
</table>

**Note:** Effects of adopting counterfactual quantitative easing policies during the COVID-19 crisis. Changes relative to the HP-filtered trend at quarterly frequency. Increases in the real exchange rate denote depreciations. Asset purchases are as a share of steady state GDP. Ranges in square brackets are 90% confidence intervals. *This row presents a counterfactual to the baseline economy under the assumption that policy rates stay constant at their 2019Q4 level relative to a HP-trend. The remaining rows represent the outcome of counterfactual exercises that only differ in QE policies relative to this row.
The effects of QE policies do not depend on declining US interest rates

Table 6: The efficacy of EME central bank asset purchases does not change under no monetary policy easing in the US

<table>
<thead>
<tr>
<th></th>
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<th>2020Q2</th>
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<th>2020Q2</th>
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<td>(6)</td>
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<tr>
<td>Excess LC</td>
<td>Annualized basis point change</td>
<td>% change</td>
<td>Annualized basis point change</td>
<td>% of GDP</td>
<td>Annualized basis point change</td>
<td>% change</td>
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<tr>
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<td>public QE</td>
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</table>

Note: Effects of adopting counterfactual quantitative easing policies during the COVID-19 crisis. Changes relative to the HP-filtered trend at quarterly frequency. Increases in the real exchange rate denote depreciations. Asset purchases are as a share of steady state GDP. Ranges in square brackets are 90% confidence intervals.
Baseline QE policy under shock uncertainty

**Note:** Effects of adopting baseline quantitative easing policies during the COVID-19 crisis under shock uncertainty. Deviations from a HP-trend. The dashed lines are the basis for filtering shocks (under the baseline QE policy regime) to match variable paths in the out-of-estimation sample of 2020Q1-2020Q3. Foreign-held government bonds share is assumed to stay at its 2020Q2 level relative to its trend due to lack of data.
Counterfactual no QE policy under shock uncertainty

Note: Effects of adopting no quantitative easing policies during the COVID-19 crisis under shock uncertainty. Deviations from a HP-trend. The dashed lines are the basis for filtering shocks to match variable paths (under the baseline QE policy regime) in the out-of-estimation sample of 2020Q1-2020Q3.
Counterfactual aggressive public QE policy under shock uncertainty

Note: Effects of adopting aggressive public bond purchases during the COVID-19 crisis under shock uncertainty. Deviations from a HP-trend. The dashed lines are the basis for filtering shocks to match variable paths (under the baseline QE policy regime) in the out-of-estimation sample of 2020Q1-2020Q3. Foreign-held government bonds share is assumed to stay at its 2020Q2 level relative to its trend due to lack of data.
Counterfactual aggressive private QE policy under shock uncertainty

Note: Effects of adopting aggressive private security purchases during the COVID-19 crisis under shock uncertainty. Deviations from a HP-trend. The dashed lines are the basis for filtering shocks to match variable paths (under the baseline QE policy regime) in the out-of-estimation sample of 2020Q1-2020Q3. Foreign-held government bonds share is assumed to stay at its 2020Q2 level relative to its trend due to lack of data.
Counterfactual aggressive (AE-type) public QE policy under shock uncertainty

Note: Effects of adopting (advanced economy-type) aggressive public bond purchases during the COVID-19 crisis under shock uncertainty. Deviations from a HP-trend. The dashed lines are the basis for filtering shocks to match variable paths (under the baseline QE policy regime) in the out-of-estimation sample of 2020Q1-2020Q3. Foreign-held government bonds share is assumed to stay at its 2020Q2 level relative to its trend due to lack of data.
Counterfactual aggressive (AE-type) private QE policy under shock uncertainty

Note: Effects of adopting (advanced economy-type) aggressive private bond purchases during the COVID-19 crisis under shock uncertainty. Deviations from a HP-trend. The dashed lines are the basis for filtering shocks to match variable paths (under the baseline QE policy regime) in the out-of-estimation sample of 2020Q1-2020Q3. Foreign-held government bonds share is assumed to stay at its 2020Q2 level relative to its trend due to lack of data.